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AN ANALYSIS
OF THE
MOTOR VEHICLE
REPAIR TRADE

• MECHANICAL •



PREPARED BY
A NATIONAL COMMITTEE
APPOINTED BY
THE DEPARTMENT OF LABOUR
OTTAWA, CANADA

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AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

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INTRODUCTION

The first National Conference on Apprenticeship in Trades and Industries held at Ottawa in May 1952, recommended that the Federal Government be requested to co-operate with Provincial apprenticeship committees and others concerned in preparing analyses of a number of skilled occupations. In implementing this recommendation, the Vocational Training Branch of the Federal Department of Labour has appointed a number of committees, each of which has compiled an analysis of one trade.

In the case of the Motor Vehicle Repair Trade a committee of four experienced teacher-tradesmen was appointed and the organization meeting was held in Montreal on December 3, 1956. Mr. J. R. Reid, Supervisor of Apprenticeship for the Alberta Department of Labour was named to represent the four Western provinces; Mr. Mervin J. McGuffin, Chief Instructor in the trade in the H.B. Beal Technical School, London, to represent Ontario; Mr. Joseph B. Carignan, Chief instructor in electricity and carburetion at the Automobile School in Montreal, represented the Province of Quebec and the fourth member, representing the four Maritime provinces was Mr. Lucide Rioux, instructor in this trade at the Grand Falls School in New Brunswick. The committee was convened by Mr. S. R. Ross, Supervisor of Trade Training for the Federal Department of Labour, Ottawa, Canada.

SCOPE OF THE ANALYSIS

While regulations controlling the Motor Vehicle Repair Trade vary somewhat province to province, the elements and techniques are universal and common to all. It was therefore only necessary to delimit the scope of the work to be considered as the basis of this analysis. It was accordingly decided to deal with only those phases of the trade that are commonly considered as comprising the mechanical field.

Having these limitations in mind, the committee has endeavoured to include all operations of the trade that are considered essential in each and every province. In other words, this would be an analysis of such a nature that officials in each province would agree that the operations and knowledge related thereto are complete as the basis of training competent mechanics.

Because of the unvarying nature of the work, the journeyman mechanic applies his techniques in precisely the same manner whether in Newfoundland or in British Columbia. There is little opportunity for the individual to display creativeness because he is not called upon to make or produce any component parts as is the case in some other trades. There is correspondingly less opportunity for personal planning since many of the sequences are outlined in manuals provided by the service divisions of the various motor car manufacturers.

INTRODUCTION

Even though this is the case, there is still a most important technique, that of determining the causes of unsatisfactory operation. This calls for keen observation and analysis to determine the procedures necessary to gain desired results. Expert analysis is of course based on a thorough knowledge of the functioning of each component.

In view of the abstract nature of this phase of the trade, the committee urges that emphasis be placed on the 'why' of procedures, so that as the trainee progresses, he will develop a fundamental grasp of the techniques of skilful troubleshooting, which is so important. This phase of training should be given prominent consideration by all who use this analysis as a guide to instruction and by those who extract courses of study therefrom.

It should be noted that this analysis is not a course of study nor is it intended that items be undertaken in the sequence shown. It is, however, a compilation of essential operations in the mechanical phases of this trade which a fully trained journeyman should be able to perform and also of those items of related knowledge which he should have mastered.

In certain localities, there may be additional techniques in which a journeyman might need to be proficient if he is to render as complete a service as opportunity affords. One such is welding but the committee considers this as an extraneous skill and not an essential part of this trade. It therefore has not been included. This applies as well to Body Repair, Refinishing and Painting as well as to Upholstering. The committee further recommends that the apprentice be introduced to procedures involved in estimating costs of repair work although this is not a prerequisite to journeyman status.

There are certain other elements which will be included automatically in a well planned training program. Such elements will consider personal safety in all the varying situations with which the trainee will be confronted and also will stress necessary precautions in the handling of components to guard against damaging them during disassembling, storing and re-assembling. Orderliness and cleanliness, the care and use of all hand tools, machine tools and other shop equipment should be stressed as a matter of routine. Because of the miscellaneous nature of these items the committee has decided not to indicate them repeatedly throughout the analysis but at the same time wishes to emphasize their importance.

PROCEDURE

At the outset, Directors of Apprenticeship agreed to have their provinces represented as indicated above. This ensured that the final compilation would be generally acceptable and would be considered as the national basis of instruction in this trade.

INTRODUCTION

Each committee member agreed to compile a main division of the analysis and to refer his work, as it progressed to the others for critical examination. It was felt that this procedure would ensure the validity of each part and guarantee the national aspect of the whole. Each of these main divisions comprises a series of Blocks, each of which is a group of Units. In turn, each Unit is sub-divided into a number of Operations with Related Knowledge clearly indicated.

PURPOSES AND USES OF ANALYSIS

By the whole-hearted co-operation of the Directors of Apprenticeship and others this analysis promises to be a standardizing influence in the training of apprentices. This desirable goal will be more nearly realized because the Directors have agreed, on an experimental basis, that the completion examination for all apprentices in Canada will be set by one province for one year and by another province for the next year, and so on. Such a country-wide approach can contribute to uniform training and can facilitate the transfer of credits for apprentices from province to province.

The committee recommends this analysis as a guide to foremen and others who do training on the job; as a basis of programs in industry and for courses of study in vocational schools, trade institutes and other centres; as a yardstick by which the previous experience of newcomers or others may be evaluated.

It is the sincere hope of the committee that this effort will contribute to the nation-wide development of apprenticeship training and will generate a real zeal for uniformly expert craftsmanship in this trade.

The committee desires to express its appreciation to officials of the motor car manufacturing companies for their co-operation in reviewing the work and acting as advisors during its preparation.

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BLOCK 1: Miscellaneous Procedures: General Shop Practice

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AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 1: Hand Tools and Operations

OPERATIONS

KNOWLEDGE

1. Installing a screw in wood or metal	(a) Types of screw drivers (b) Sizes of screw drivers (c) Use and care of screw drivers
2. Installing a nut or bolt	(a) Types of wrenches, including torque wrenches (b) Sizes of wrenches (c) Use and care of wrenches
3. Cutting and holding a piece of wire	(a) Common types of pliers e.g. combination and side cutting (b) Special types of pliers e.g. brake spring and battery (c) Use and care of pliers
4. Driving out a pin, plain or taper	(a) Types of hammers (b) Sizes of hammers (c) Use and care of hammers (d) Types of punches (e) Sizes of punches (f) Use and care of punches
5. Cutting a rivet	(a) Types of chisels (b) Sizes of chisels (c) Use and care of chisels
6. Measuring length, inside and outside diameter of steel stock	(a) Types of rules, steel squares and protractors (b) Use and care of rules, steel squares and protractors (c) Types of calipers (d) Use and care of calipers (e) Mathematics: addition, subtraction, fractions and angles

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 1: Hand Tools and Operations

OPERATIONS

KNOWLEDGE

7. Measuring inside and outside diameter to thousandths	(a) Types of micrometers (b) Sizes of micrometers (c) Use and care of micrometers (d) Mathematics: Addition, subtraction, fractions and decimal equivalents
8. Measuring inside diameters, using gauges	(a) Types of hole gauges (b) Sizes of hole gauges (c) Use and care of hole gauges (d) Related mathematics

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 2: Use of Fastenings and Fittings

OPERATIONS

KNOWLEDGE

1. Installing a bolt or nut	(a) Types of thread (b) Number of threads per inch (c) Types of heads e.g. Hexagon (d) Types of nuts e.g. Castellated, Self-locking, Interference, Pal, Clinch
2. Using various washers	(a) Types of washers (b) Sizes of washers (c) Uses of washers
3. Replacing a pin or key	(a) Types of pins and keys (b) Sizes of pins and keys (c) Uses of pins and keys
4. Selecting the proper screw	(a) Types of screws e.g. Wood, Sheetmetal (b) Sizes of screws (c) Uses of screws
5. Measuring a thread	(a) Measuring with a thread gauge (b) Measuring without a thread gauge
6. Cutting a thread: Internal, external	(a) Types of taps (b) Sizes of taps (c) Use and care of taps (d) Use of tap handles (e) Types of dies (f) Sizes of dies (g) Use and care of dies (h) Use of die handles
7. Removing a broken stud	(a) Types of extractors (b) Improvised methods

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 2: Use of Fastenings and Fittings

OPERATIONS

KNOWLEDGE

8. Installing a snap ring

- (a) Types of snap rings
- (b) Uses of snap rings
- (c) Methods of installation

9. Installing pipe fittings

- (a) Types of pipe fittings, brass, etc.
- (b) Types of pipe threads
- (c) Materials used in pipe fittings
- (d) Corresponding items for hose and hose adapters

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 3: Bench Work and Power Tools

OPERATIONS

KNOWLEDGE

1. Cutting stock with a hacksaw

- (a) Types of saws e.g. hand and power
- (b) Sizes of each type
- (c) Uses of each type
- (d) Types of blades
- (e) Sizes of blades
- (f) Uses of each type
- (g) Methods of operating saws and cutting speeds

2. Filing to produce a plane surface

- (a) Types of files
- (b) Sizes of files
- (c) Methods of operating files e.g. Posture, positioning work in vise, strokes per minute

3. Locating a center

- (a) Layout methods
- (b) Use of dividers, surface gauges, hermaphrodites

4. Heating a soldering copper

- (a) Types of blow torches
- (b) Uses and care of blow torches
- (c) Types of fluid used in blow torches

5. Soldering a joint

- (a) Types and sizes of soldering coppers
- (b) Care of soldering coppers
- (c) Tinning soldering coppers
- (d) Types of cleaners and fluxes
- (e) Types of solder and their application on different metals

6. Sharpening a drill bit

- (a) Types of grinders
- (b) Types of grinding wheels
- (c) Use and care of grinders
- (d) Drill bit cutting angles
- (e) Methods used when sharpening a drill bit

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 3: Bench Work and Power Tools

OPERATIONS

KNOWLEDGE

7. Sharpening a chisel	(a) Types of metal (b) Heat treatment: Tempering, etc. (c) Forging
8. Drilling a hole in metal	(a) Types of drill bits (b) Sizes of drill bits (c) Use and care of drill bits (d) Types of electric drills and drill presses (e) Use and care of drills and drill presses (f) Methods of operation e.g. use of a pilot hole
9. Fitting a bushing	(a) Types and sizes of reamers (b) Use and care of reamers (c) Types of hones and honing equipment (d) Use and care of honing equipment (e) Bushing fitting methods e.g. press fit, thumb fit
10. Inspecting a bearing	(a) Types of bearings (b) Methods of removal and installation (c) Methods of cleaning and inspecting
11. Inspecting an oil seal	(a) Types of oil seals (b) Methods of removal and installation (c) Care of oil seals
12. Making a gasket	(a) Types of gasket material (b) Methods of making a gasket (c) Types and uses of gasket cement

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 4: Hazardous Procedures

OPERATIONS

KNOWLEDGE

1. Lifting a car

- (a) Types of jacks and hoists
- (b) Use of jacks and hoists
- (c) Types of safety stands
- (d) Use of safety stands
- (e) Safe personal working habits

2. Operating power equipment

- (a) First-aid methods and injury reports
- (b) Safe personal working habits while operating hydraulic presses, pullers and centrifugal units
- (c) Use and importance of safety signs e.g. NEVER adjust or oil while in operation

3. Preventing and/or extinguishing a fire

- (a) Types of fire extinguishers
- (b) Uses of fire extinguishers
- (c) Methods of sending in fire alarms
- (d) Methods of preventing spontaneous combustion fires and other types
- (e) Methods of venting areas where volatile fluids are used

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 1: General Shop Practice

UNIT 5: Auto Body Care

OPERATIONS	KNOWLEDGE
1. Cleaning the automobile	(a) Use of foam type upholstery cleaners (b) Use of volatile type upholstery cleaners (c) Use of special brushes, sponges, etc. (d) Methods of cleaning: 1. Convertible tops 2. White wall tires 3. Genuine and imitation leather 4. Outside finishes (e) Methods of polishing outside finishes
2. Adjusting body parts	(a) Methods of checking and adjusting: 1. Convertible folding tops 2. Door latches and locks 3. Trunk latches and locks 4. Hood latches and locks (b) Methods of checking and repairing: 1. Grilles and grille bar rattles 2. Windows and window rail rattles 3. Bodies and body to frame rattles 4. Bumpers and bumper brackets
3. Installing accessories	(a) Methods of installing: 1. Radio antennae 2. Front wheel static collectors 3. Hood ground clips and condensers 4. Receivers and back speakers 5. Heaters and air-conditioners

BLOCK 2: Miscellaneous Procedures: Running Gear

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7: Checking turning radius	
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2: Servicing the power unit	

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 2: Running Gear

UNIT 1: Suspension

OPERATIONS	KNOWLEDGE
1. Positioning and repairing frames and axles	(a) Types and construction of frames (b) Materials used in frames (c) The effect broken or distorted frames have on steering (d) Methods of aligning bent frames and positioning rear axles (e) Types and components of front wheel suspension (f) Methods of straightening and repairing front and rear axles
2. Replacing a spring	(a) Types and characteristics of coil and leaf springs (b) Types of torsion bar suspension (c) Types of shackles and spring seats (d) Reasons for and results of spring sag
3. Replacing a shock absorber	(a) Types of shock absorbers (b) Sizes and characteristics of shock absorbers (c) Methods of servicing shock absorbers and stabilizer bars (d) Types of shock absorber fluids

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 2: Running Gear

UNIT 2: Wheels and Tires

OPERATIONS

KNOWLEDGE

1. Removing a wheel	(a) Types of wheels, rims and hubs (b) Types of wheel fasteners
2. Balancing a wheel-assembly	(a) Methods of cleaning and inflating tires (b) Types of wheel balancers (c) Methods of mounting and operating wheel balancers (d) Methods of correcting static and dynamic unbalance (e) Types of wheel weights
3. Replacing a wheel	(a) Methods of wheel positioning (b) Methods of fastening, and setting tension (c) Methods of replacing hub caps, special wheel rims, etc.
4: Repairing a tire	(a) Types, sizes and construction of tires and tubes (b) Methods of removing and inspecting tires and tubes (c) Methods of repairing tires, and tubes (d) Effects on tires of incorrect air pressure (e) Effects on tires of incorrect steering angles

BLOCK 2: Running Gear

UNIT 3: Steering Alignment

OPERATIONS

KNOWLEDGE

1: Centering a car on an aligner	(a) Types and construction of steering aligners (b) Methods of installing checking heads, jacks, lights etc.
2: Determining points of wear	(a) Methods of checking and correcting: 1. Wheel bearing wear 2. Wheel run out 3. Steering linkage 4. Tire inflation 5. Tracking and shock absorbers
3. Adjusting camber	(a) Meaning of camber (b) Purpose of camber (c) Method of measuring and correcting camber
4: Adjusting Caster	(a) Meaning of caster (b) Purpose of caster (c) Methods of measuring and correcting caster
5: Adjusting toe-in	(a) Meaning of toe-in (b) Purpose of toe-in (c) Method of measuring and adjusting toe-in
6: Checking king-pin inclination	(a) Meaning of king-pin inclination (b) Purpose of king-pin inclination (c) Methods of adjusting e.g. bending straight front axles
7: Checking turning radius	(a) Meaning of turning radius (b) Purpose of turning radius (c) Methods of measuring and correcting turning radius angles
8: Adjusting the steering gear	(a) Purpose of steering box adjustments (b) Methods used in making steering box adjustments (c) Methods of adjusting steering linkage

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 2: Running Gear

UNIT 4: Power Steering

OPERATIONS

1: Aligning power steering

(a) Items in Block 2 Unit 3

2: Servicing the power unit

- (a) Pascal's principle
- (b) Types and operation of power steering
- (c) Types of hydraulic fluids
- (d) Methods of making mechanical adjustments
- (e) Methods of servicing the pump, control valves, lines and steering gear
- (f) Methods of bleeding and trouble shooting the system

BLOCK 3: Miscellaneous Procedures: Brakes - Hydraulic, Vacuum, Air

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AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 3: Brakes

UNIT 1: Hydraulic, Vacuum, Air

OPERATIONS

KNOWLEDGE

1. Repairing cylinders	(a) Importance of cleanliness (b) Methods used in reconditioning wheel and master cylinder (c) Methods used in brake-line service
2. Replacing brake drums, shoes and linings	(a) Methods used in reconditioning and replacing: drums, linings, shoes, brake leverage and linkage
3. Adjusting brakes	(a) Methods of flushing brake systems (b) Methods of filling and bleeding. Type of fluid (c) Methods of making major and minor adjustments (d) Methods of relining and adjusting parking brakes (e) Methods of freeing and lubricating brake parts
4. Repairing power brakes	(a) Purpose, types construction and operation (b) Methods of cleaning, repairing and adjusting (c) Types of pumps and operating pressures (d) Methods of cleaning, repairing and adjusting

NOTE: Certain components of the modern motor car are designed around and function because of certain basic scientific principles. It is intended that these principles and general information should be dealt with in a formal class-room lecture series and not necessarily be dependent upon and tied to manipulative shop procedures.

Scientific topics and items of general knowledge such as the following should be covered: Pascal's principles, pressure and vacuum, classes and principle of levers, brake pedals and linkage, parking brakes, friction and materials to resist same, study of wheel assemblies, brake cylinders (vacuum, air, fluid) and miscellaneous accessories.

BLOCK 4: Miscellaneous Procedures: Lubrication - Lubricants and Lubricating

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AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 4: Lubrication

UNIT 1: Lubricants and Lubricating

OPERATIONS

KNOWLEDGE

1. Pressure testing the engine lubricating system	(a) Types and operation of oiling systems (b) Types and use of pressure testers (c) Types and purpose of oil filters (d) Methods of flushing and servicing the system (e) Types and operation of oil pressure regulators
2. Lubricating the vehicle	(a) Types and use of manufacturers' lubrication charts (b) Methods of application and types of lubricants used in the following: 1. Steering gear units and steering pivot points 2. Conventional and automatic transmissions 3. Universal joints, differentials and rear axle bearings 4. Front wheel bearings 5. Engine crankcase breathers and air cleaners 6. Starters, generators and distributors 7. Clutch and brake linkage 8. Speedometer and brake cables
3. Lubricating body parts	(a) Methods of cleaning and lubricating: 1. Door, deck and hood locks 2. Door hinges and striker plates 3. Door check, link, shoes and rollers 4. Hood latches

NOTE: Items of related information of general interest in connection with the above operations are as follows: methods used in refining crude oil; types, viscosity and service ratings of oils; types of additives and detergents; types, grades and service ratings of greases.

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AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 5: Clutches

UNIT 1: Removing and Installing
Clutch Assembly

OPERATIONS

KNOWLEDGE

1. Removing clutch assembly	(a) Purpose of clutch (b) Clutch nomenclature (c) Clutch construction (d) Clutch operation (e) Types of clutches (coil spring, diaphragm, crown pressure)
2. Installing clutch assembly	(a) Proper tightening sequence (b) Purpose of clutch balancing (c) Methods of clutch balancing (d) Testing for proper clutch operation (e) Alignment arbors: Types and purpose

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 5: Clutches

UNIT 2: Clutch Discs

OPERATIONS

KNOWLEDGE

1. Checking facings for wear	(a) Friction and its properties (b) Clutch facing materials (c) Dry type clutch discs (d) Wet type clutch discs (e) Single and multiple disc types (f) Causes of normal and abnormal facing wear
2. Checking discs for defects	(a) Vibration dampening devices (b) Causes of chattering, grabbing, slipping or dragging (c) Purpose of disc waves
3. Testing disc alignment	(a) Methods of setting up and using dial indicator (b) Permissible limits or tolerances
4. Refacing clutch discs	(a) Method of removing clutch facing rivets (b) Method of riveting facings to clutch discs

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 5: Clutches

UNIT 3: Flywheel

OPERATIONS

KNOWLEDGE

1. Inspecting for ridges, scores or cracks

(a) Causes of damage to flywheel:
Accidents, slippage, worn facings, dirt, etc.

2. Testing for misalignment

(a) Permissible limits
(b) Use of dial indicator

3. Removing and installing clutch shaft pilot bearing

(a) Types of pilot bearings
(b) Use of special pullers
(c) Purpose of pilot bearing
(d) Methods of determining bearing condition
(e) Use of special drivers

4. Lubricating pilot bearing

(a) Type of lubricant to use
(b) How to clean and lubricate pilot bearings

OPERATIONS

KNOWLEDGE

1. Inspecting assembly for wear	(a) Purpose of pressure plate (b) Types of pressure plate units: Coil-spring diaphragm, crown pressure spring, semi-centrifugal (c) Construction of pressure plates - Metals used
2. Inspecting pressure plate for scores, warpage or burns	(a) Causes of scoring, warping or burning (heat cracks) (b) Use of straight edge (c) Permissible limits
3. Disassembling pressure plate and cover	(a) Methods of using special fixtures
4. Testing pressure plate springs	(a) Methods and equipment used (b) Importance of equalized spring pressures (c) Identification of different colors of springs
5. Inspecting and replacing release lever bearings	(a) Types of bearings: Needle, ball, roller, solid (b) Sizes and ratings of bearings (c) Methods of determining serviceability of bearings
6. Assembling pressure plate and cover	(a) Lubrication of pivot points
7. Adjusting release levers	(a) Importance of accurate adjustments (b) Use of special fixtures (c) Levers, fulcrums, pivots (d) Purpose and operation of semi-centrifugal release levers (e) Manufacturers' specifications

BLOCK 5: Clutches

UNIT 5: Release Bearings

OPERATIONS

KNOWLEDGE

1. Cleaning release bearings	(a) Types of release bearings (b) Proper use of cleaning solvents (c) Purpose of release bearings (d) Operation of release bearings (e) Thrust bearing principles
2. Inspecting release bearings	(a) How to determine serviceability of release bearings (b) Causes of release bearing failures
3. Replacing release bearings	(a) Use of arbor press (b) Use of hydraulic press
4. Inspecting and replacing release bearing hubs	(a) Methods of mounting release bearing hubs to forks (b) Use of micrometer to check OD against specification
5. Lubricating release bearings	(a) Types of bearing lubricants (b) Methods of lubricating release bearings (c) Factory or pre-lubricated release bearings

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 5: Clutches

UNIT 6: Clutch Linkage

OPERATIONS

KNOWLEDGE

1. Inspecting clutch linkage for wear or binding	(a) Cause and possible results of clutch linkage wear (b) Cause and possible results of binding linkage (c) Determining serviceability of clutch linkage (d) Operation of over-center springs
2. Removing and replacing clutch linkage	(a) Methods used to lock or retain clutch linkage (b) Lubrication of clutch linkage
3. Adjusting clutch linkage	(a) Clutch pedal clearances (b) Clutch pedal free travel (c) Importance of correct adjustments

OPERATIONS

KNOWLEDGE

1. Removing fluid couplings	(a) Operating principles (b) Fluid coupling components (c) Advantages of fluid couplings (d) Disadvantages of fluid couplings (e) Importance of noting balance marks (f) Causes of heat generation (g) Foaming and its causes
2. Draining and refilling fluid couplings	(a) Type of oil used (b) Method of checking oil level (c) Methods used to prevent over-filling (d) Causes and possible results of oil leakage
3. Replacing shaft seals	(a) Types of oil seals (b) Oil seal materials and construction (c) Special tools required to remove and install oil seals (d) Special precautions involved in replacing fluid coupling oil seals
4. Installing Fluid Couplings	(a) Use of alignment arbors (b) Precautions

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 5: Clutches

UNIT 8: Torque Converters

OPERATIONS

KNOWLEDGE

1. Removing torque converters

- (a) Torque converter principles and ratios
- (b) Torque converter components
- (c) Advantages of torque converters
- (d) Types of torque converters
- (e) Meaning of torque, centrifugal force, vortex
- (f) Methods used to direct fluid flow
- (g) Purpose and operation of over-running clutch
- (h) Use of alignment arbors

2. Draining torque converters

- (a) Torque converter fluids
- (b) Methods used to cool same

3. Installing torque converters

- (a) Precautions
- (b) Methods of checking for proper operation

BLOCK 6: Power Trains - Transmissions

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3: Assembling Automatic Transmission	
4: Installing Automatic Transmission	
5: Making External Adjustments	

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 6: Transmissions

UNIT 1: Removing and Installing
Transmission

OPERATIONS

KNOWLEDGE

1. Removing a transmission	(a) Purpose of transmission (b) Draining lubricant (c) Removal of members etc. to permit accessibility to transmission (d) Necessity of using pilot studs (e) Use of engine and car-support fixtures
2. Checking clutch housing alignment and bore run-out	(a) Use of special arbor (b) Use of service manuals (c) Use of dial indicator
3. Installing a transmission	(a) Selection of proper lubricant (b) Methods of refilling transmission (c) Possible results of insufficient or improper lubricant (d) Methods of checking transmission for proper operation

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 6: Transmissions

UNIT 2: Disassembling, Inspecting and Assembling Transmission

OPERATIONS

KNOWLEDGE

1. Disassembling three-speed transmission	(a) Principles of gearing (b) Gear ratios (mechanical advantages) (c) Types of gears: Spur, bevel, helical (d) Types of transmissions: 3 and 4 speed, synchromesh, constant mesh (e) Methods of tracing power flow (f) Removal of Welch plugs (g) Purpose and operation of detent balls, shifter rails, forks, interlocks (h) Methods of locking counter shaft, idler shaft
2. Disassembling and inspecting synchromesh unit	(a) Purpose of synchromesh (b) Synchromesh operation (c) Methods of removing and installing snap-rings (d) Special tools and bench-stands
3. Inspecting transmission components for wear or damage	(a) Causes of wear or damage (b) Removal and installation of oil seals (c) Gasket materials (d) Mainshaft end-play (e) Causes of gear noises
4. Assembling three-speed transmission	(a) Gear alignment and tooth contact (b) Permissible counter-shaft end-play (c) Proper location of counter-shaft thrust washers (d) Installation of Welch plugs (e) Reasons for using new gaskets and snap rings
5. Adjusting shifting linkage	(a) Importance of proper adjustments (b) Shifting linkages (rods, cables) (c) Shifting assists (vacuum, electric) (d) Proper lubrication

BLOCK 6: Transmissions

UNIT 3: Overdrives

OPERATIONS

KNOWLEDGE

1. Removing and disassembling overdrive	(a) Principles of overdrive (b) Operation of overdrive (c) Advantages of overdrive (d) Speeds at which overdrive cuts in or out (e) Overdrive lock-out mechanism (f) Overdrive step-down mechanism (g) Tracing flow of power (h) Causes of overdrive failure to engage or dis-engage
2. Assembling and installing overdrive	(a) Methods of tracing and testing electrical circuits (b) Methods of checking and adjusting control linkages (c) Purpose and operation of relays and solenoids (d) Purpose and operation of governors (e) Methods of cleaning and adjusting solenoid contact points (f) Methods of adjusting solenoid throttle switch and kick-down switch (g) Overdrive lubrication (h) Methods of testing overdrive for proper operation

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 6: Transmissions

UNIT 4: Automatic Transmissions

OPERATIONS

KNOWLEDGE

1. Removing automatic transmissions

- (a) Methods of draining automatic transmissions before removal
- (b) Purpose and advantages of automatic transmissions
- (c) Purpose and methods of cooling automatic transmission fluid
- (d) Types of automatic transmissions

2. Disassembling and inspecting automatic transmissions

- (a) Use of special tools and bench stands
- (b) Names of components
- (c) Types of automatic transmission oil pumps
- (d) Methods of checking oil pumps and pressure relief valves
- (e) Operation and construction of automatic transmission clutches and brake bands
- (f) Methods of tracing internal oil circuit
- (g) Operation of servoes
- (h) Tracing flow of power at various speeds
- (i) Determining serviceability of various components
- (j) Causes of automatic transmission failure

3. Assembling automatic transmissions

- (a) Methods and specifications for internal adjustments
- (b) Special tools and gauges required
- (c) Lubrication
- (d) Methods of testing circuits, e.g. compressed air

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 6: Transmissions

UNIT 4: Automatic Transmissions

OPERATIONS

KNOWLEDGE

4. Installing automatic transmissions

- (a) Use of aligning arbors
- (b) Methods of fastening automatic transmissions and fluid couplings or torque converters to flywheel

5. Making external adjustments

- (a) Road testing procedures
- (b) Methods of adjusting controls

NOTE: The apprentice is required to master only general information and basic principles common to all automatic transmissions. The analysis indicates the limits of such instruction in anticipation that he will pursue further study and possibly specialized training in this field. Specific data may be secured from specifications of the various manufacturers.

BLOCK 7: Power Trains - Universal Joints

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AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 7: Universal Joints

UNIT 1: Servicing Universal Joints

OPERATIONS

KNOWLEDGE

1. Removing and disassembling ball and trunnion universal joints	(a) Purpose of universal joints (b) Operation of universal joints (c) Types of universal joints (d) Purpose of universal joint boots (e) Use of hydraulic and arbor presses
2. Assembling and installing ball and trunnion universal joints	(a) Methods of determining serviceability of parts (b) Permissible off-center limits of trunnion pin (c) Method of checking position of trunnion pin in shaft
3. Removing and disassembling two-yoke and cross universal joints	(a) Methods of removing lock-rings (b) Methods of cleaning and inspecting universal joint needle bearings
4. Assembling and installing two-yoke and cross universal joints	(a) Importance of using new locking devices (b) Methods of lubrication (c) Types of lubricants (d) Causes of universal joint failure (e) Purpose of arrows on some universal joints

BLOCK 8: Power Trains - Propeller Shafts

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2: Removing, Checking and Installing Hotchkiss Drive Propeller Shafts	39
3: Lubricating Ball and Slip Joints	39

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 8: Propeller Shaft

UNIT 1: Servicing Propeller Shafts

OPERATIONS

KNOWLEDGE

1. Removing, checking and installing torque-tube and shaft

- (a) Function of propeller shaft
- (b) Types of drives: Torque-tube, Hotchkiss
- (c) Purpose of truss rods
- (d) Meaning of rear-end torque
- (e) Purpose and operation of ball joints
- (f) Purpose and operation of slip joints
- (g) Method of adjusting ball joints
- (h) Methods of checking propeller shaft for balance and alignment
- (i) Reasons for using hollow drive shaft

2. Removing, checking and installing Hotchkiss drive propeller shaft

- (a) Advantages of Hotchkiss drive
- (b) Meaning of forward thrust
- (c) How drive is transmitted by torque-tube and Hotchkiss drives

3. Lubricating ball and slip joints

- (a) Use of proper lubricants
- (b) Methods of lubrication
- (c) Methods of adjusting ball joints

BLOCK 9: Power Trains - Differentials

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4: Removing and Installing Differential Side Bearings	
5: Assembling and Adjusting Differential	
6: Removing and Installing Drive Pinion, Bearings and Oil Seals	

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 9: Differentials

UNIT 1: Removing and Replacing Rear
Axe Aseмbly

OPERATIONS

KNOWLEDGE

1. Removing rear axle assembly

- (a) Methods used to support car
- (b) Types of rear suspensions
- (c) Methods of checking rear axle housing alignment
- (d) Types of rear axle housings
- (e) Function of torque arms
- (f) Two speed rear axles

2. Installing and aligning rear
axle assembly

- (a) Methods of checking and aligning rear axle assembly
- (b) Meaning of axle ratio
- (c) Methods of determining axle ratio

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 9: Differentials

UNIT 2: Removing and Installing
Differential Carrier Assembly

OPERATIONS

KNOWLEDGE

1. Removing differential carrier assembly

- (a) Methods of draining lubricant
- (b) Methods of flushing differential assembly
- (c) Carrier assembly components

2. Installing and lubricating differential carrier assembly

- (a) Use of extreme pressure lubricants
- (b) Use of hypoid gear lubricants
- (c) Importance of not mixing different brands of hypoid gear lubricants
- (d) Meaning of active and inactive gear lubricants
- (e) Method of interpreting viscosity ratings and lubrication charts

BLOCK 9: Differentials

UNIT 3: Disassembling, Checking and Reassembling Differential

OPERATIONS

KNOWLEDGE

1. Disassembling differential

- (a) Purpose of differential
- (b) Operation of differential
- (c) Differential components
- (d) Types of differential ring-gears and pinions: Spur, bevel, hypoid and worm
- (e) Differential gear ratios
- (f) Advantages of hypoid gearing
- (g) Tracing the power flow
- (h) Meaning of torque and foot-pounds

2. Removing and installing differential ring-gear

- (a) Method of removing rivets
- (b) Methods of re-attaching ring-gear to differential case
- (c) Use of special bench fixtures

3. Checking ring-gear run-out

- (a) Use of dial indicator

4. Removing and installing differential side bearings

- (a) Use of special pullers and drivers
- (b) Conditions affecting serviceability of bearings

5. Assembling and adjusting differential

- (a) Method of checking backlash
- (b) Purpose and method of adjusting backlash
- (c) Purpose and method of checking and adjusting tooth contact
- (d) Method of pre-loading bearings
- (e) Purpose of pre-loading bearings
- (f) Causes of gear noises
- (g) Adjustment crown gear thrust pad

6. Removing and installing drive pinion, bearings and oil seals

- (a) Method of removing oil seals
- (b) Method of installing oil seals
- (c) Methods of adjusting drive pinion bearings

BLOCK 10: Power Trains - Rear Axles

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Block Ten - One Unit

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5: Removing and Replacing Broken Rear Axle	45

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 10: Rear Axles

UNIT 1: Removing, Checking and
Installing Rear Axles

OPERATIONS

KNOWLEDGE

1. Removing, checking and installing semi-floating rear axle

- (a) Differences between live and dead axles
- (b) Types of live rear axles: Semi-floating, three-quarter floating, full-floating
- (c) Use of special axle pullers
- (d) Methods of checking and adjusting rear axle end-play
- (e) Methods of checking rear axle shaft alignment
- (f) Methods of adjusting rear axle bearings
- (g) Forces acting on axle

2. Removing, checking and installing three-quarter floating rear axle

- (a) Types of bearings used on different types of rear axles
- (b) Forces acting on axle

3. Removing, checking and installing full-floating rear axle

- (a) Methods of retaining and adjusting axle bearings
- (b) Forces acting on axle

4. Removing and installing rear axle bearings and oil seals

- (a) Use of special axle bearing pullers
- (b) Pre-lubrication of oil seals
- (c) Use of special bearing and oil seal drivers
- (d) Methods of checking bearing condition
- (e) Types of oil seals and oil deflectors

5. Removing and replacing broken rear axle

- (a) Possible causes of rear axle breakage
- (b) Methods of removal and replacing axle flange bolts
- (c) Importance of eliminating excessive backlash

Block 11: Fuel and Exhaust Systems - Basic Science Related to Carburetion

TABLE OF CONTENTS

Block Eleven - One Unit

The topics indicated below are items of basic knowledge and information which should be familiar to journeymen and therefore should be included in the training of apprentices.

1. Function and types of Carburetor: Up-draft and down-draft.
2. Air: Composition, density, atmospheric pressure; affect of pressure on vapor point of a liquid; vacuum as measured in inches of mercury.
3. Products of Crude Oil: diesel oil, fuel oil, gasoline and liquified petroleum.
4. Gasoline: Nature and density; cracking process, molecules, light fractions, heavy fractions, explosive mixtures - rich, lean, economy and power mixture; anti-knock, tetraethyl lead, octane number; vaporization and atomization.
5. By-products of Combustion: Carbon dioxide, carbon monoxide water vapor, sulphur.
6. Blueprint and Diagram Reading (Manuals, sectional drawings, etc.) to determine construction, adjustments, etc.
7. Fuel injection: Diesel fuel.

Block 12: Fuel and Exhaust Systems - Carburetors

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Unit 1: Single Barrel Carburetor Page 48

- Operation 1: Disassembling the Carburetor
- 2: Checking the Idling Circuit
- 3: Checking the Main Circuit
- 4: Checking the Power Circuit
- 5: Checking the Accelerating Circuit
- 6: Checking and Adjusting the Float Level
- 7: Checking and Adjusting the Automatic Choke
- 8: Checking the Auxiliary Components
- 9: Repairing or Replacing Defective Parts
- 10: Trouble Finding

Unit 2: Dual and Quadruple Barrel Carburetor Page 51

- Operation 1: Disassembling the Carburetor
- 2: Checking Idling Circuits
- 3: Checking Main Circuits
- 4: Checking Power Circuits
- 5: Checking Accelerating Circuits
- 6: Checking and Adjusting Float Level
- 7: Checking and Adjusting Automatic Choke
- 8: Checking Auxiliary Components
- 9: Repairing or Replacing Defective Parts
- 10: Trouble Finding

OPERATIONS

KNOWLEDGE

1. Disassembling the carburetor	(a) Proper tools to use. Specifications (b) Cleaning solutions (c) Sub-assembly parts: air horn, main body, throttle body, linkage (d) Properties of metals: die castings, white metal (e) Construction and function of individual parts: choke valve, air breather, throttle valve, concentric float chamber, float, needle valve and seat; Mixing chamber, venturi, discharge nozzle and jets, metering plugs, metering pins and air bleeds
2. Checking the idling & fast idling circuits and component parts	(a) Purpose of the idling circuits (b) Functioning of the idling speed circuits: Path of the gasoline, path of the air Relation of the discharge ports to the throttle valve Idling mixture screw, idling speed screw Methods of metering gasoline and air to the circuits Purpose of the fast idling circuit Relation of the fast idling discharge port to the throttle valve position (c) Position of the choke valve during warming up period
3. Checking the main circuit	(a) Purpose of the main circuit; transition phase (b) Functioning of the main circuit: Path of the gasoline and air Methods of metering gasoline to the discharge nozzle: Metering pins, metering plugs Purpose of the jets, air bleeds, primary and secondary venturi, jet size (c) Mixing: mixture ratio, economy mixture, turbulence, atomization (d) Function of the anti-percolator. Adjustments (e) Metering pin setting gauge

OPERATIONS

KNOWLEDGE

4. Checking the power circuit and component parts

- (a) Purpose of the circuit
- (b) Functioning of the circuit:
 - Path of the gasoline and air
 - Methods of metering the gasoline
 - Vacuum metering and channels
 - Mixture ratio, Power mixture
 - Time control of the power circuit

5. Checking the accelerating circuit and component parts

- (a) Purpose of the circuit
- (b) Functioning of the circuit:
 - Path of the gasoline. Aiming of the jet
 - Function of the check valves
 - Seasonal adjustment of the piston stroke. Pump linkage
 - Mixture ratio during acceleration
 - Time duration of the injection - Prolonged injection - aiming the jet
- (c) Types of pump: piston, diaphragm
- (d) Pump setting gauge

6. Checking and adjusting the float level

- (a) Types of float used
- (b) Importance of proper float setting
- (c) Use of float setting gauges
- (d) Single & double float system
- (e) Needle valve and seat assembly
- (f) Causes of needle sticking-Needle valve seating pressure

7. Checking and adjusting the automatic choke

- (a) Function of the automatic choke
- (b) Types of automatic choke: direct mounting - manifold mounting
- (c) Functioning of the automatic choke
- (d) Unbalanced choke valve
- (e) Thermostat spring heating control: hot air-electrical
- (f) Thermostatic spring adjustment
- (g) Choke cracking device - Unloading device
- (h) Fast idling device
- (i) Linkage adjustment

OPERATIONS

KNOWLEDGE

8. Checking the auxiliary components	(a) Function of the air filter, types of air filter. Servicing air filter (b) Function of the dash pot, types of slow closing throttle devices. Adjustment (c) Purpose & functioning of carburetor mounted starter switch. Adjustment (d) Purpose & functioning of kick down switch (e) Purpose & functioning of the manifold heat control valve
9. Repairing or replacing defective parts	(a) How to file and lap mating surfaces according to manufacturers' manuals (b) How to inspect and replace gaskets according to specifications
10. Trouble finding	(a) Effect of air leak at the manifold gaskets (b) Effect of low float setting (c) Effect of high float setting (d) Effect of improper mixture (e) How to determine the proportion of the mixture with a gas analyser (f) Effect of a rich mixture, a lean mixture. Causes (g) Effect of a leak at the power valve (h) Effect of a leak in the vacuum passage to the power cylinder (i) Effect of a leak at the check valves (j) Causes of poor acceleration (k) Effect of choke valve not closing or opening properly (l) Effect of improper functioning of the heat control valve (m) Causes and effect of carburetor icing

OPERATIONS

KNOWLEDGE

Note: Some general information is required as in corresponding operations in connection with Single Carburetors. Additional applicable features are listed below.

1. Disassembling the carburetor	(a) Purpose of dual and quadruple carburetors
2. Checking the idling and fast idling circuits and component parts	(a) Inter-relation of the idling circuits (b) Synchronism of the throttle valves (c) Cylinders fed by each carburetor (d) Inter-relation of throttle valve linkage (four barrels) (e) Purpose of secondary throttle valve locking device (four barrels) (f) Idling speed adjusting screws
3. Checking the main circuits and component parts	(a) Inter-relation of main circuits (b) Linkage time control of the secondary throttle opening (four barrels) (c) Vacuum time-control of the secondary throttle opening (four barrels) (d) Purpose of auxiliary valves above secondary throttle valves (four barrels)
4. Checking the power circuits and component parts	(a) Inter-relation of the power circuits
5. Checking the accelerating circuits and component parts	(a) Inter-relation of the accelerating circuits (b) Mechanical or vacuum controlled pumps.
6. Checking and adjusting the float setting	(a) Inter-relation of float chambers (b) Gas level stability control (c) Float motion damping device
7. Checking and adjusting the automatic choke	(a) Choke valve arrangement (b) Inter-relation of choke valve and auxiliary valves of secondary carburetor (four barrels) (c) Inter-connection between choke valve and throttle valves (four barrels)
8. Checking auxiliary components, replacing defective parts and trouble finding	(a) Conditions that warrant replacing parts

Block 13: Fuel and Exhaust Systems - Fuel and Vacuum Pumps

TABLE OF CONTENTS

Unit 1: Fuel Pumps Page 53

- Operation 1. Disassembling the pump
- 2. Checking the cover assembly
- 3. Checking the body assembly
- 4. Repairing or replacing defective parts
- 5. Trouble finding

Unit 2: Fuel and Vacuum Pump Combined Page 55

- Operation 1. Disassembling the pump
- 2. Checking the cover assembly
- 3. Checking the body assembly
- 4. Repairing and replacing defective parts
- 5. Trouble finding

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 13: Fuel and Vacuum Pumps

UNIT 1: Fuel Pumps

OPERATIONS

KNOWLEDGE

1. Disassembling the pump	(a) Function of the pump (b) Types of pumps: mechanical, electrical (c) Direct or remote actuation (d) Mounting methods (e) Sub assembly: Cover, body, filter, linkage (f) Type of pipe fittings
2. Checking the cover assembly	(a) Types, function and location of the valves (b) Function of the air dome chamber (c) Path of the gas through the cover (d) Type of filtering element. Methods of fastening cover to the body
3. Checking the body assembly	(a) Variable diaphragm stroke controlled by float level (b) Composition of the diaphragm (c) Pumping action of the diaphragm. Pump pressure control (d) Function of the diaphragm spring (e) Events taking place on the compression stroke of the diaphragm (f) Events taking place during the intake stroke of the diaphragm (g) Overrunning rocker arm drive to diaphragm stem (h) Overdrive, underdrive rocker arm. Function of rocker arm spring (i) Straightness of the mating surfaces
4. Repairing or replacing defective parts	(a) Study of the manual instructions (b) Proper methods of assembling parts
5. Testing fuel pump in place	(a) How to test for capacity (b) How to test for pressure (c) Pump pressure range (d) How to test pump vacuum

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 13: Fuel and Vacuum Pumps

UNIT 1: Fuel Pumps

OPERATIONS

6. Trouble finding

- (a) Causes and effect of excess pressure
- (b) Causes and effect of insufficient pressure
- (c) Effect of worn linkage
- (d) Causes and effect of insufficient pump capacity
- (e) Causes and effect of vapor lock
- (f) Advantages of pusher electric pump over mechanical suction pump

KNOWLEDGE

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 13: Fuel and Vacuum Pumps

UNIT 2: Combined Type

OPERATIONS

KNOWLEDGE

1. Disassembling the pump	(a) Function and operation of the fuel and vacuum pump
2. Checking the cover assembly	(a) Difference in construction between the fuel and vacuum covers (b) Path of the gas through fuel cover (c) Path of the air through vacuum pump cover (d) Difference between fuel and vacuum check valves (e) Manifold vacuum and vacuum pump in series (f) Rest periods of the vacuum pump (g) Variable fuel diaphragm stroke controlled by the float level (h) Variable vacuum diaphragm stroke controlled by engine vacuum
3. Checking the body assembly	(a) Mounting of the fuel and vacuum diaphragm (b) Overrunning rocker arm links (c) Function of the vacuum diaphragm spring (d) Purpose of the larger vacuum pump diaphragm (e) Factors controlling the fuel pump capacity (f) Factors controlling the vacuum pump capacity
4. Repairing or replacing the defective parts	(a) Study of the manual instructions (b) Proper methods of assembling parts
5. Testing dual pump in place	(a) How to test fuel pump pressure and capacity (b) How to test the vacuum valve of the vacuum pump

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 13: Fuel and Vacuum Pumps

UNIT 2: Combined Type

OPERATIONS	KNOWLEDGE
6. Trouble finding	<ul style="list-style-type: none">(a) Causes and effect of excessive fuel pressure(b) Causes and effect of insufficient fuel pressure(c) Causes and effect of insufficient pump capacity(d) Effect of air leaks at the suction line of the vacuum pump(e) Effect of leaky vacuum pump valves(f) Causes of oil being sucked into the intake manifold

Block 14: Fuel and Exhaust Systems - Components of the Carburetion System

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3. Checking Air Filter and Silencer	58
4. Checking the Muffler	58
5. Checking diesel fuel injection system	59
6. Trouble finding	59

BLOCK 14: Components of the Carburetion System

UNIT 1: Servicing Procedures

OPERATIONS

KNOWLEDGE

1. Checking the gas tank	(a) Tank mounting. Components of the tank (b) Type of gas level indicator tank unit (c) Provision for sediment separation (d) How to syphon gas out of tank (e) Risk of vapor lock between tank and pump (f) Necessity of air vent at the tank filler pipe (g) Importance of air tight fuel pipe fittings (h) Causes of water condensation in the tank (i) Related science: Pressure on a liquid and its vapor point
2. Checking intake manifold and components parts	(a) Function and location of the manifold gaskets (b) Manifold balanced circuits. Manifold variable cross section (c) Function and location of the heat riser (d) Function and location of the heat valve (e) Thermostatic control and adjustment of the heat valve (f) Relation of the intake to the exhaust manifolds
3. Checking and servicing the air filter and silencer	(a) Types of filter. Mounting of the air filter (b) Function of the air filter. Function of the resonating chambers
4. Replacing the muffler	(a) Function of the muffler (b) Construction and location of the muffler (c) Back pressure created by the exhaust circuit (d) Related science: Acoustics - Sound waves

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 14: Components of the
Carburetion System

UNIT 1: Servicing Procedures

OPERATIONS

KNOWLEDGE

5. Checking diesel fuel injection system

(a) Principle of fuel injection
(b) Components of injection system

6. Trouble finding

(a) Causes and effect of water condensation in fuel system
(b) Causes and effect of vapor lock
(c) Causes and effect of air leaks at the manifold gaskets
(d) Effect of a heat valve not operating properly
(e) Effect of a clogged air filter
(f) Causes and effect of back pressure in the exhaust circuit
(g) Causes and effect of lean mixture

Block 15: Electrical Systems - Basic Science

TABLE OF CONTENTS

Study of the topics indicated below provides basic knowledge and information which should be familiar to journeymen in the mechanical phases of the trade and therefore should be included in the training program.

1. Study of current, both AC and DC, voltage, voltage drop, amperage
2. Definition of conductor, insulator, terminal, generator
3. Definition of circuit (1) closed (2) open (3) short (4) series (5) parallel
4. Study of resistance (Ohm's Law), watt, power
5. Definition of magnetism, magnetic field, lines of force, poles (i) positive (ii) negative, magnetic circuit, electro-magnet
6. Advantages of the 12 volt system

Note: The trade recognizes the complexity of power driven devices and of the circuits controlling same and accordingly agrees that the auto-mechanic need be required to master only such features as the following (a) the layout of circuits (b) the function of various components (c) the nature and use of measuring instruments such as the voltmeter and ammeter.

Block 16: Electrical Systems - The Battery

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Operation	Page
1. Servicing the Battery	62
2. Testing the Battery	62
3. Charging the Battery	62
4. Repairing	62
5. Trouble Finding	63

OPERATIONS

KNOWLEDGE

1. Servicing the battery	(a) Function of the battery (b) Types of battery: lead-iron-nickel (c) Function of the components: plates, separators, cell, electrolyte (d) Reactions taking place during charge and discharge (e) Active material-Reaction with acid (f) Connection of cells and voltage (g) Batteries connected in series, in parallel (h) Care of batteries in storage (i) How to remove, fasten and replace cables
2. Testing the battery	(a) Capacity test: slow discharge, heavy discharge (b) High rate discharge tester (c) Level of the electrolyte (d) Temperature effect on capacity (e) Battery rating (f) Science related to specific gravity, hydrometer, distilled water, sulphuric acid
3. Charging the battery	(a) How to tell when a battery is charged (b) Chargers: bulb charger, constant potential charger, rapid charger, trickle charger. Charging current and voltage (c) How to prepare the electrolyte (d) Battery self discharge at rest (e) Battery charging temperatures (f) Temperature effect on electrolyte conductivity (g) Safety: Explosive gas formation
4. Repairing a battery	(a) Rebuilding a battery post (b) Replacing a battery case (c) Replacing a cell cover (d) Resealing with battery pitch (e) Corrosion preventive

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 16: Battery

UNIT 1: Servicing

OPERATIONS

KNOWLEDGE

5. Trouble finding

- (a) Causes and effect of sulphation
- (b) Causes and effect of plate shedding
- (c) Causes and effect of overheated plates
- (d) Separator trouble
- (e) Post corrosion
- (f) Causes and effect of overcharge
- (g) Causes and effect of undercharge

Block 17: Electrical Systems - The Generator

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Block Seventeen - One Unit

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2. Testing the Generator	65
3. Repairing and installing the Generator	66
4. Trouble Finding	66

OPERATIONS

KNOWLEDGE

1. Removing and disassembling the generator

- (a) Function of the generator; driving methods; belt tension; pulley removal
- (b) Construction and purpose of the component parts: armature, commutator, field coils, field poles, brushes, brush springs, bearings
- (c) Two pole, four pole generator
- (d) Armature circuit, field circuit, air gap and its effect
- (e) Difference between a three brush and shunt generator
- (f) Position of the third brush and effect on the charging rate
- (g) Offset brushes. Reaction brush holder
- (h) Connection of the armature coils to the commutator bars
- (i) Path of the current through the armature circuit
- (j) Path of the current through the field circuit
- (k) Terminal "F" to ground type of generator
- (l) Terminal "F" to terminal "A" type of generator

2. Testing the generator

- (a) Testers used: 110 volt test leads, 6 volt test leads, growler, ammeter, voltmeter
- (b) How to test armature coils for shorted, opened, grounded, resistance and reversed coils; standard test procedure
- (c) How to test field coils for conditions in (b) above
- (d) Condition of the commutator
- (e) Provision for lubrication of bearing and bushing; how to test bearings
- (f) Motoring the generator
- (g) How to locate the neutral point on commutator
- (h) How to test armature run out, commutator run out
- (i) Brushes: composition, hard brush, semi-hard brush, soft brush. Brush alignment and seating
- (j) Brush position on the commutator
- (k) How to test the brush carrier
- (l) How to test brush spring tension, the armature air gap
- (m) Brushes end plate. Aligning marks or dowel pins
- (n) How to test generator in place

OPERATIONS

KNOWLEDGE

3. Repairing and installing the generator

- (a) How to resolder armature coil leads to commutator
- (b) How to true-up a commutator on the lathe
- (c) Why and how to undercut the mica. Mica undercutter
- (d) Bearing removal and replacement
- (e) How to remove and replace a bushing. Reaming the bushing
- (f) How to polarize the generator
- (g) How to replace field coils & poles
- (h) How to test polarity of field coils & poles
- (i) How to seat brushes
- (j) How to locate the brushes lengthwise on the commutator

4. Trouble finding

- (a) Causes and effect of generator over-heating
- (b) Causes and effect of brush arcing
- (c) What causes an armature to burn
- (d) What causes the field coils to burn
- (e) Causes of commutator bars pitting
- (f) Causes of generator low out-put
- (g) Causes of generator high out-put
- (h) Causes of bearing failure

Block 18: Electrical Systems - Charging Circuits

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Operation 1. Checking	
2. Repairing and adjusting	
3. Trouble finding	
Unit 2: Miscellaneous procedures	Page 69
Operation 1. Checking and adjusting the	
charging circuit	
2. Trouble finding	

BLOCK 18: Charging Circuits

UNIT 1: Voltage and current regulator and cut-out relay

OPERATIONS

KNOWLEDGE

1. Checking the voltage and current regulator and cut-out relay

- (a) Function of the regulators
- Function of the cut-out
- (b) Purpose of the components: magnet core, voltage winding, series winding, field resistance, induced current by-pass resistance
- (c) Path of the current in the voltage regulator circuit
- (d) Path of the current in the current regulator circuit
- (e) Path of the current in the cut out circuit
- (f) Closing voltage of the cut-out points, reversed opening current. Two steps closing of the Autolite cut-out points
- (g) Vibrating voltage regulator, two steps voltage regulator
- (h) Polarity and its effect on metal deposit
- (i) Oxidation of points and corrective methods
- (j) Current carrying capacity of regulator points
- (k) How to test regulator in place

2. Repairing and adjusting

- (a) How to change the closing and opening operating point of the cut-out relay
- (b) How to change the operating voltage of the V.R.
- (c) How to change the operating current of the C.R.
- (d) Air gap setting. Effect on vibration frequency
- (e) Demagnetizing winding
- (f) Use of ohmmeter. Effect of resistance on the sparking of regulator points. Effect of resistance on the induced voltage
- (g) Regulator points replacement
- (h) Temperature compensation
- (i) Polarity: direction of current through regulator points, metals used for regulator points
- (j) Causes of oxidation of the regulator points; how to clean contact points
- (k) Cushion mounted regulator box
- (l) Necessity of perfect grounding the regulators
- (m) How to clean contact points

3. Trouble finding

- (a) Effect of oxidized points
- (b) Causes of low charging current
- (c) Causes of high charging current
- (d) Causes of vibrating cut-out points
- (e) Effect of defective grounding of the regulators

OPERATIONS

KNOWLEDGE

<p>1. Checking and adjusting the charging circuit</p> <p>2. Trouble finding</p>	<ul style="list-style-type: none"> (a) How to test the battery (b) How to test conductors, insulators, terminals, junction blocks (c) How to connect the voltmeter and ammeter in the circuit (d) Function of the charging resistance (e) How to change the value of the current and voltage (f) How to determine the polarity of the circuit (g) Difference between the 6 and 12 volts system (h) Study of the specifications (i) Winter and summer setting of the voltage regulator (j) Path of the current through the circuit (k) Relation of all the circuits to the charging circuit (l) How to determine the voltage drop of the charging circuit (m) Parasitic resistance and their effects (n) Ammeter location in the circuit and its indications (o) How to locate the defective parts of the circuit in place (p) Location and function of the charge indicator-light <ul style="list-style-type: none"> (a) Causes and effect of excessive voltage drop (b) Effect of undersized conductors (c) Causes of undercharged battery (d) Causes of overcharged battery
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Block 19: Electrical Systems - Ignition

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2. Testing and repairing the breaker mechanism and distributor	
3. Testing and adjusting spark plugs	
Unit 2: Miscellaneous Techniques	Page 73
Operation 1. Checking the Ignition Circuit	
2. Spark timing	
3. Trouble finding	

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 19: Ignition

UNIT 1: Various Components
and Procedures

OPERATIONS

KNOWLEDGE

1. Testing the coil

- (a) Function of the coil
- (b) Construction of the coil. Primary & secondary winding
- (c) Factors controlling the secondary induced voltage and current
- (d) Voltage peak insulation. Oil & dry insulation
- (e) Operation of coil tester: spark gap type, electronic type
- (f) Coil capacity: Heavy duty coil, standard coil
- (g) Transformer action of the coil
- (h) Relation between capacity of coil and condenser
- (i) Coil polarity
- (j) Coil saturation period

2. Testing & repairing
the breaker mechanism
and distributor

- (a) Function of the breaker mechanism
- (b) Cam angle. Effect of large & small cam angle
- (c) Breaker points construction & mounting
- (d) Double set of points system; Advantages
- (e) Purpose & function of condenser: Leakage, damping, capacity tests
- (f) Purpose & functioning of centrifugal advance
Test of the advance on a distributor tester
- (g) Functioning and use of a distributor tester
- (h) Purpose & functioning of the vacuum advance
Test of the vacuum advance
- (i) Effect of spring tension on the breaker points action. Test of the spring tension
- (j) Relation between condenser capacity and gap of points
- (k) Check of the cam wobble
- (l) Replacement of cam shaft bushings
- (m) Rotor & distributor cap insulation
- (n) Purpose of the rotor air gap
- (o) Cap inserts corrosion - Preventive methods
- (p) How to clean contact points
- (q) How to synchronize double breakers
- (r) Setting gap for same
- (s) Lubrication
- (t) How to time double breakers

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 19: Ignition

UNIT 1: Various Components
and Procedures

OPERATIONS

KNOWLEDGE

3. Testing & adjusting
spark plugs

- (a) Construction & function of the spark plug
- (b) Heat range: hot & cold plugs
- (c) Radio interference. Elimination with resistor
- (d) Sand blast cleaning
- (e) Plug gapping. Compromise between low & high speed requisite
- (f) Tightening pressure & shell distortion
- (g) Plug size and heat dissipation
- (h) Use of spark plug tester
- (i) How to test spark plugs in and out of place
- (j) Gaskets and various types of seats

OPERATIONS

KNOWLEDGE

1. Checking the ignition circuit

- (a) Function of the primary & secondary circuits
- (b) Transfer of energy from primary to secondary
- (c) Factors controlling the quality of the spark
- (d) Oscillatory discharge at the spark plug
- (e) Factors controlling the induced voltage at the secondary
- (f) Function of a resistance at the coil
- (g) Comparison of 6 & 12 volts systems
- (h) Voltage drop in the circuit
- (i) Coronary effects
- (j) Length of the secondary circuit and capacity effect
- (k) Secondary cables shield and capacity effect
- (l) Added resistance in the secondary and its effect on the condenser capacity
- (m) Check of the secondary cables

2. Ignition timing

- (a) Use of timing light. Timing to the timing mark
- (b) Timing to the knocking or 'pinging' point
- (c) Function & setting of ignition timing for fuels of various octane ratings
- (d) Check of the centrifugal advance with timing light
- (e) Check of the vacuum advance with timing light
- (f) Determination of the firing order
- (g) Factors controlling the spark timing. Use of vacuum gauge

3. Trouble finding

- (a) Causes & effect of pitted breaker points, burned points
- (b) Causes & effect of pre-ignition (spark knock)
- (c) Causes of open throttle miss
- (d) Causes of high speed miss
- (e) Causes of ignition knock
- (f) Causes of low speed miss
- (g) Causes of radio interference

Block 20: Electrical Systems - Starters

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2. Testing and Repairing the Starter	
3. Testing and Adjusting the Starter Switch	
4. Trouble finding	
Unit 2: Starter Circuits	Page 77
Operation 1. Check and Adjust Starter Circuit	
2. Trouble Finding	

BLOCK 20: Starters

UNIT 1: Servicing the Starter and Starter Switch

OPERATIONS

KNOWLEDGE

1. Removing and disassembling the starter

- (a) Functioning principle of the starter
- (b) Construction & purpose of the component parts: Armature, commutator, field coils, field poles, brushes
- (c) Two pole, four pole starter
- (d) Armature circuit, field circuits
- (e) Air gap and its effect
- (f) Starter drives; construction & operation
- (g) Difference between 6, 12 and 24 volt starter
- (h) Why higher voltage circuits are more efficient
- (i) Factors controlling the power of the starter
- (j) Related science: Inertia, thermal and electrical conductivity, shock absorbing devices

2. Testing and repairing the starter

- (a) Testers used: 110 volt test leads, six volt test leads, growler, ammeter, voltmeter
- (b) How to test for shorted, open and grounded armature coils; also for high resistance in soldered joints
- (c) How to test for shorted, open, grounded and high resistance field coils
- (d) Condition of the commutator
- (e) Armature bushings wear and its effect on the air gap
- (f) Brushes: Location on the commutator, composition, spring tension, alignment, seating, replacing
- (g) Free running test. Cranking test
- (h) Lock torque test. Voltage drop test
- (i) How to test starter drive
- (j) How to true up the commutator
- (k) How to undercut mica
- (l) How to ream and replace bushings
- (m) How to remove and replace a ring gear
- (n) How to replace field coils

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 20: Starters

UNIT 1: Servicing the Starter and
Starter Switch

OPERATIONS

KNOWLEDGE

3. Testing & adjusting
starter switch

- (a) Types of switch: manual, solenoid
- (b) Solenoid principle
- (c) Solenoid windings: pulling, holding coils
- (d) Relay operated solenoid; adjustment
- (e) Switch contact pressure & voltage drop

4. Trouble finding

- (a) Causes & effect of starter over-heating
- (b) Causes & effect of brush arcing
- (c) Effect of improperly adjusted solenoid relay
- (d) Causes of insufficient power

OPERATIONS

KNOWLEDGE

1. Checking & adjusting starter circuit

- (a) Functioning and use of a shunt ammeter
- (b) Capacity test of the battery
- (c) Gauge and current carrying capacity of cables
- (d) Corrosion of the battery posts. Ground connection
- (e) Voltage drop produced by the starter current and its effect on the ignition circuit
- (f) Determination of the cranking current
- (g) Determination of the cranking voltage
- (h) Rest periods and battery recuperation
- (i) Voltage drop allowed in the circuit
- (j) Path of the current in the solenoid relay circuit
- (k) Path of the current in the solenoid winding circuits
- (l) Path of the current in the starter circuits

2. Trouble finding

- (a) Causes of low cranking speed
- (b) Causes of drive pinion not meshing (Bendix)
- (c) Causes of drive pinion failure to disengage
- (d) Causes of armature coils forced out of the slots
- (e) Causes of Bendix drive pinion locking on the ring gear

Block 21: Electrical Systems - Lighting

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2: Checking and adjusting	
(a) Tail light circuit	
(b) Stop light circuit	
(c) Licence light circuit	
(d) Parking light circuit	
3: Trouble finding	
Unit 2: Auxiliary Circuits	Page 80
Operation 1: Checking such circuits as dome light, trunk light	
2: Checking directional light circuits	

OPERATIONS

KNOWLEDGE

1. Checking and adjusting headlight circuits

- (a) Types of sealed beams: glass unit, composite unit
- (b) Assembly and mounting of the sealed beam lamps. Function of reflector, lens and filament
- (c) Lamp rating: Candle power, wattage
- (d) Driving beam, passing beam, aiming alignment
- (e) Switches: Main lighting switch, high-low beam
- (f) Circuit protection: Fuses, circuit breakers
- (g) Path of the current through the circuit
- (h) Voltage drop in the circuit with 6 and 12 volt bulbs
- (i) Purpose of a lighting circuit relay
- (j) Wire color code, wire gauges
- (k) Tracing a circuit in wiring diagrams
- (l) Parallel and series circuits. Type and location of connectors
- (m) Sealed beam unit replacement and adjusting
- (n) Related science: Light diffusion through crystal, parabolic reflector, focal point, illuminating distances, stopping distances
- (o) How to detect and locate short circuits

2. Checking and adjusting circuits for:

Parking lights
Tail lights
Stop lights
Back-up lights

- (a) Operation, location and mounting of parking lights and switches for same
- (b) Also tail lights, stop lights and back-up lights
- (c) Light bulb rating (candle power)

3. Trouble finding

- (a) Causes of dull headlights
- (b) Causes of light intensity fluctuating with the speed
- (c) Causes of short bulb life
- (d) Effect of improper grounding

OPERATIONS

KNOWLEDGE

1. Checking the auxiliary light circuits	(a) Function and location of instrument lights (b) Function and location of the dome light, trunk light (c) Wire gauge and color code. Bulb rating in candle power (d) Function and location of the backing up lights (e) Circuit protection: Fuses, circuit breakers (f) Purpose of junction blocks, fuse block
2. Checking directional light circuits	(a) Function and location of the turn signal lights (b) Importance of using bulbs of proper candle power (c) Functioning and testing of the flasher unit (d) Construction and functioning of the switch (e) Automatic return to the "off" position (f) Checking the circuits with voltmeter

Block 22: Electrical Systems - Accessories

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2: Trouble finding	
Unit 2: Windshield Wipers and Washers	Page 83
Operation 1: Checking and adjusting the wiper and component	
2: Trouble finding	

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 22: Accessories

UNIT 1: Horns

OPERATIONS

KNOWLEDGE

1. Checking and adjusting the horn	(a) Types of horn: rotary, vibrator (b) Function of horn sub-assembly: electro magnet, armature, diaphragm breaker points (c) By-passing the induced current with a condenser or a resistance (d) Induced voltage at the opening of the points (e) Adjustment controlling the pitch of the sound (f) Adjustment controlling the intensity of the sound (g) Dual pitch horns. Blending of tones (h) Purpose and functioning of the horn relay (i) Mounting of the horn button or ring on the steering wheel (j) Path of the current through the horn button circuit (k) Path of the current through the horn circuit (l) Purpose of a flexible horn mounting (m) Science: Sound, principle of the muffler, tone blending, vibration frequency
2. Trouble finding	(a) Causes of sound distortion (b) Causes of points sticking (c) Causes of intermittent operations (d) Causes of horn breaker-points pitting and burning

BLOCK 22: Accessories

UNIT 2: Windshield Wipers and Washers

OPERATIONS

KNOWLEDGE

1. Servicing windshield wipers and washers

- (a) Methods of mounting wiper components
- Types of wiper motors: vacuum, electric
- (b) Types of transmission: Links, cables
- (c) Wiper blade construction and mounting
- (d) Functioning of the vacuum motor
- (e) Functioning of the electric motor
- (f) Automatic blade parking circuit
- (g) Two speed electric motor
- (h) Path of the current through the circuit

2. Trouble finding

- (a) Effect of air leak on a vacuum-actuated wiper
- (b) Causes of sluggish wiper operation
- (c) Causes of failure to operate

BLOCK 23: Electrical Systems - Gauge Circuits

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2: Checking water temperature gauge circuit	85
3: Checking oil pressure gauge circuit	85

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 23: Gauge Circuits

UNIT 1: Servicing Various Components

OPERATIONS

KNOWLEDGE

1. Checking the dash fuel gauge or light circuit	(a) Fuel tank unit: construction, functioning (b) Dash unit types: magnetic, thermal. Construction & functioning (c) Path of the current through the circuit (d) How to test tank and dash units
2. Checking the water temperature gauge circuit	(a) Engine unit: construction & functioning (b) Dash unit: construction & functioning (c) Bi-metal thermostatic action (d) Path of the current through the circuit (e) How to test engine & dash unit
3. Checking the oil pressure gauge circuit	(a) Engine unit: construction & functioning (b) Dash unit: construction & functioning (c) Path of the current through the circuit (d) How to test engine & dash units

Block 24: Motor Tune-up - Miscellaneous Techniques

TABLE OF CONTENTS

Block Twenty-four - One Unit

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3. Checking and Adjusting the Fuel System	87
4. Checking and Adjusting the Cooling System	88
5. Checking and Adjusting the Lubricating System	88
6. Checking Motor Performance Before and after Tune-up .	88

OPERATIONS

KNOWLEDGE

1. Checking compression

- (a) Factors controlling the performance of a motor
- (b) How to determine the compression ratio
- (c) Factors controlling the compression: Valves, rings, cylinders, pistons, lubricating oil, piston speed
- (d) Increased power due to high compression
- (e) Compression proportional to throttle opening
- (f) Allowable variation in compression between cylinders
- (g) How to tell if compression leak exists at the valves or cylinders
- (h) Relation between compression and vacuum

2. Checking the ignition system
(Refer to Block 19)

- (a) Factors controlling the quality of the spark
- (b) How to test the quality of the spark
- (c) How to set the spark timing
- (d) Factors affecting the spark timing: Gasoline octane number, compression value, carbonized chambers

3. Checking and adjusting the fuel system
(Refer to Blocks 12 and 13)

- (a) How to test the pump pressure
- (b) How to test the pump capacity
- (c) How to check the float setting and gas level
- (d) How to check the choke operation
- (e) How to check the carburetor linkage
- (f) How to adjust the idling speed. Use of the tachometer
- (g) Automatic transmission idling speed setting in drive position. Automatic transmission idling speed in neutral position
- (h) How to check the fast idling cam position and linkage
- (i) How to adjust the idling speed mixture with vacuum gauge and gas analyser
- (j) How to check main, power and acceleration circuits with gas analyser
- (k) How to check the functioning of the manifold heat control valve
- (l) Effect of rich and lean mixtures on: Operating temperature of the motor, power produced, economy
- (m) Cause of blue black and white smoke at the exhaust

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 24: Motor Tune-up

UNIT 1: Miscellaneous Techniques

OPERATIONS

KNOWLEDGE

4. Checking & adjusting cooling system	(a) Refer to Block 26 on cooling system
5. Checking & adjusting lubricating system	(a) Refer to Block 4 on lubricating system
6. Checking motor performance before and after tune-up operations	(a) Factors controlling engine vacuum (b) Principle of the vacuum gauge (c) Use of vacuum gauge to determine valve condition, ring condition, condition of carburetion system, spark and valve timing (d) Use of vacuum gauge to compare output of each cylinder, individually

Block 25: Electrical Systems: Power Actuated Units

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Block Twenty-Five - One Unit

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2. Checking circuits for power actuated tops and components	90
3. Checking circuits for power actuated seats and components	90
4. Trouble finding	90

OPERATIONS

KNOWLEDGE

1. Checking circuits for electric window lifts and components	(a) Components of window lift mechanism: motor, switch, relays, circuit breaker, linkage (b) How to reverse the rotation of a D.C. motor (c) How the motor is protected from overload (d) Linkage between motor and glass. Free action in glass run channels (e) Functioning of double poles, double throw switches (f) Functioning of the relays (g) Path of the current through door switch circuits (h) Path of the current through motor circuits (i) Checking current draw with ammeter
2. Checking circuits for power actuated tops and components	(a) Components of the power-top mechanism: motor, switch, relay, pump, hydraulic cylinder, linkage (b) Functioning of the electric circuits (c) Functioning of the hydraulic circuits (d) Motor protection from overload (e) Checking current draw with ammeter
3. Checking circuits for power actuated seats and components	(a) Components of power seat mechanism: motor, switch, relay, jack screws, linkage (b) Circuits controlling the fore and aft motion of the seat (c) Circuits controlling the up and down motion of the seat (d) Arrangement of the seat runners (e) Checking current draw with ammeter
4. Trouble finding	(a) Causes of motor overheating (b) Causes of sluggish operation (c) Voltage drop caused by parasitic resistance (d) Nature of relay and switch troubles

BLOCK 26: Engines: Accessories and Components - Cooling System

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Block Twenty-Six - One Unit

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6: Removing and replacing expansion plug	92
7: Removing and replacing fan assembly	93
8: Removing, reconditioning and replacing water pump	93
9: Winterizing by use of anti-freeze	93
10: Checking cooling system for leaks	93

OPERATIONS	KNOWLEDGE
1. Draining, flushing and filling cooling system	(a) Location of drain cocks (b) Effect of cold liquid on hot metal (c) Filling levels (d) Air locks (e) Advantages of normal operating temperatures (f) How to connect and properly use pressure gun (g) Types and value of flushing solutions
2. Removing and replacing hose connections	(a) Hose clamps - types and locations (b) Moulded and straight hose (c) Troubles occurring with hose connections and hoses
3. Removing and replacing a thermostat	(a) How coolant is circulated (b) Types and operation of thermostats (c) How to test a thermostat (d) Thermostat by-passes and why used (e) Thermostat troubles
4. Removing and replacing radiators	(a) Types and construction of radiators (b) Radiator pressure caps, purpose and how to test (c) Troubles occurring with radiators and how to repair (excepting core leaks)
5. Removing and replacing water-distributing tube	(a) How heat is transmitted (b) The effect of an improperly installed water-distributing tube (c) The effect of foreign deposits in the passageways
6. Removing and replacing expansion plug	(a) What holds the plug in position (b) Precautions necessary

BLOCK 26: Cooling System

UNIT 1: Servicing Procedures

OPERATIONS

KNOWLEDGE

7. Removing and replacing fan assembly	(a) Types of fan assemblies (b) Fan belt adjustment; precautions
8. Removing, reconditioning and replacing water pump	(a) Pump construction: housing, bearings, seals, gaskets (b) Method of dismantling, repairing and assembling water pump (c) Reasons for pump failure
9. Winterizing by use of antifreeze	(a) Types of antifreeze and their characteristics (b) Specifications: volume of cooling system, amount of antifreeze required to safeguard the cooling system (c) Rust inhibitors (d) Use of antifreeze testers (e) Effect of temperatures on hydrometer readings (f) Science: density
10. Checking cooling system	(a) Cause of cooling system leaks (b) How to locate external and also internal engine leaks (c) How to make necessary repairs

BLOCK 27: Engines: Accessories and Components - Maintenance Techniques

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BLOCK 27: Engines

UNIT 1: Basic Information

This unit lists the general knowledge which the mechanic or apprentice should master so that he may intelligently diagnose troubles occurring in the automobile engine.

- (a) The Four-Stroke Cycle Principle
- (b) The Two-Stroke Cycle Principle
- (c) Modern valve timing and why used
- (d) Trade terms and their meanings:
 - Bore, stroke, T.D.C.C., etc.
- (e) Engine types: "I", "V", multiple-cylinder, etc.
- (f) Characteristics of metals and alloys used throughout engine; how they are fabricated
- (g) Purpose and function of the various parts of the engine
- (h) To find, read and understand specifications
- (i) Oil consumption - causes and remedies of over consumption
- (j) Oil loss - causes and remedies
- (k) Reasons for loss of engine compression and remedies
- (l) Reasons for low and high oil pressure
- (m) Engine knocks - how to diagnose
- (n) Engine mountings - how to adjust and replace
- (o) Repairs requiring engine removal e.g. damaged journals, broken crankshaft

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 27: Engines

UNIT 2: Oil Pan

OPERATIONS

KNOWLEDGE

1. Changing engine oil

- (a) Drain plug locations
- (b) Troubles occurring with drain plugs and how to remedy
- (c) Amount and type of engine oil to use
- (d) Necessary precautions in checking oil level
- (e) Oil characteristics
- (f) When oil filter cartridge should be changed
- (g) How to change filter cartridge: by-pass and series filter

2. Removing oil pan

- (a) How to support the engine when necessary to remove engine mounts
- (b) How to remove steering arms and rods if they interfere

3. Checking oil pan after removal

- (a) Use of guages and equipment for checking oil lines and troughs
- (b) How to check and straighten the edges of pan.
- (c) Purpose of baffles

4. Installing oil pan

- (a) How to fit pan gaskets
- (b) Precautions necessary
- (c) How to replace any supports or steering mechanism which was removed

OPERATIONS

KNOWLEDGE

1. Removing cylinder head	(a) How to drain cooling system (b) How to remove units attached to head such as - oil filter, ignition coil, horn, etc. (c) How to remove spark plugs (d) Precautions necessary in removing head nuts, bolts and head
2. Cleaning and checking head	(a) Use of carbon brushes and scrapers (b) Effects of carbon deposits (c) How to check head for warpage, cracks or damage (d) Resurfacing of head; (i) Why (ii) How much
3. Replacing cylinder head	(a) Correct installation of head gasket (b) Precaution when replacing head and retaining nuts or studs (c) Use of torque wrench (d) Interpreting specifications as to correct torque and pattern for tightening heads of various metals (e) How to replace all attached units (f) How to replace spark plugs correctly (g) How to refill cooling system

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 27: Engines

UNIT 4: Valves and Valve Operating Mechanism

OPERATIONS

KNOWLEDGE

1. Removing and replacing engine valves	(a) Precautions necessary (b) Construction of valve keepers (c) How to remove stuck valves (d) Valve stem seals
2. Cleaning, checking and refacing engine valves	(a) Valve face angles (b) Sodium filled valves (c) Amount of safe margin necessary to leave (d) Necessity of cleaning valve thoroughly (e) Effect of valve stem wear and how to check (f) How to use refacing machine
3. Cleaning, checking and replacing valve guides	(a) Use of valve guide cleaners (b) Valve guide wear and how to check (c) How to remove guides (d) How to install valve guides (e) Precautions necessary (f) Use of reamers
4. Removing, checking and replacing valve springs	(a) Construction of valve spring (b) Why two springs are used on some valves (c) Spring tension tester (d) Effect of weak valve springs (e) Close coils - correct installation (f) Valve spring retainer washers and their difference in construction (g) Anti-rattle springs and their value
5. Removing, checking, repairing and replacing valve lifters	(a) Valve lifter wear and the cause of it (b) Operation of hydraulic valve lifters (c) Use of testing equipment for hydraulic lifters (d) Use of refacing machine for refacing valve tappets (e) Precautions necessary when installing lifters

BLOCK 27: Engines

UNIT 4: Valves and Valve Operating Mechanism

OPERATIONS

KNOWLEDGE

6. Reconditioning rocker arms and shafts	(a) Precautions necessary (b) Procedure for rebushing and fitting rocker arms (c) How to clean out and check rocker arm shafts (d) Difference between exhaust and intake rocker arms (e) Correct installation of rocker arms and shafts
7. Removing and replacing valve timing cover	(a) Use of pullers (b) Precautions necessary (c) Use of alignment tools (d) Causes of oil loss around timing cover
8. Replacing oil seal in timing cover	(a) Types of oil seals (b) Oil slingers (c) Correct installation of seals (d) Precautions necessary (e) Alignment of timing cover
9. Removing and replacing camshaft drive gears and chain	(a) Use of pullers (b) Timing gear markings (c) Chain markings (d) Adjustment of timing chain (e) Composition timing gears (f) Oversize timing gears (g) Causes of chain and gear wear (h) Noise made by worn gears or chain
10. Removing and checking camshaft	(a) Precautions necessary (b) Use of micrometers and dial gauges to check wear (c) Effect of cam wear on valve operation (d) Effect of eccentric wear on fuel pump operation (e) Methods used in checking valve timing

BLOCK 27: Engines

UNIT 4: Valves and Valve Operating Mechanism

OPERATIONS

KNOWLEDGE

11. Checking camshaft bearing and replacing if necessary	(a) Use of dial guage and micrometer (b) Use of bearing pullers and drivers (c) Line reaming bearing (d) How to check bearing clearance (e) How to check and adjust end play of shaft (f) Cleaning out oil passageways
12. Reconditioning valve seats	(a) Use of valve seat refacing machine (b) Valve seat angles and width (c) Importance of clean and good valve guides (d) Types of grinding stones (e) Material used in valve seats (f) Precautions necessary (g) Use of grinding compound for checking seat and face contact
13. Replacing valve seats	(a) Expansion and contraction of metals (b) Types of seats: threaded or pressed in (c) Use of valve seat replacing tools and cutters (d) Precautions necessary
14. Adjusting tappets	(a) Effect of temperature on tappet clearance (b) Tappet locking devices (c) Use of feeler gauges (d) Required position of piston and proper stroke for setting tappets on a dead engine (e) Necessity of grinding valve stem or face to make adjustment on some models (f) Precautions necessary when adjusting hydraulic type of tappets

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 27: Engines

UNIT 5: Crankshaft, Main Bearings,
Connecting Rod Bearings, Fly-
wheel and Vibration Damper

OPERATIONS

KNOWLEDGE

1. Cleaning crankshaft	(a) Oil passage plugs (b) Oil passage holes
2. Checking truth and size of journals and crankpins	(a) Use of micrometer (b) Use of dial gauge (c) Necessary checks to make (d) Cause of shaft wear (e) Cast shaft - forged shaft (f) Allowable wear of shaft (g) Balancing: (i) Static (ii) Dynamic (h) Amount of material which may be removed by grinding (i) Possible results if incorrectly done (j) Metalizing and its characteristics
3. Checking main bearings and replacing	(a) Main bearing construction (b) Reasons for bearing failure (c) How bearing is locked in position (d) How to remove bearing (e) Line reaming (f) Use of test shims (g) Use of plastigage (h) Bearing sizes obtainable (i) End thrust bearings (j) Oil grooves and passages (k) Use of torque wrench (l) Adjustable type bearing (shims) (m) Bearing crush
4. Checking connecting rod bearings and replacing	(a) Bonded bearings (b) Bearing inserts (c) Reasons for bearing failure (d) Checking bearing clearance (e) Insert sizes (f) Connecting rod nut locking devices (g) Use of torque wrench (h) Procedures possible with engine in place; conditions requiring removal of engine

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 27: Engines

UNIT 5: Crankshaft, Main Bearings, Connecting Rod Bearings, Flywheel and Vibration Damper

OPERATIONS

KNOWLEDGE

5. Replacing rear main bearing seals	(a) Causes of oil leaks past rear main bearing seals (b) Types of seals used and precautions when installing the various types
6. Removing and replacing flywheel	(a) Procedures and precautions in supporting the engine, removing the transmission, clutch and bell housing (b) Locking devices for flywheel bolts and nuts
7. Installing flywheel ring gear	(a) Design of the teeth on the gear (b) Use of heat to expand gear (c) Importance of allowing gear to cool slowly
8. Removing and installing crankshaft vibration damper	(a) Use of pullers (b) Precautions necessary (c) How vibration dampers are held in position

BLOCK 27: Engines

UNIT 6: Connecting Rods, Piston, Piston Rings and Cylinder

OPERATIONS

KNOWLEDGE

1. Removing connecting rod and piston	(a) How to remove cylinder ridge (b) Numbering of pistons and rods
2. Removing rod from piston and replacing	(a) Piston pin mountings (b) How to remove and install piston pin locks (c) Maximum thrust side of piston
3. Fitting piston pins	(a) Use of pin hone (b) Use of reamers and broaches
4. Aligning connecting rod and piston	(a) Use of rod aligners (b) Effects of incorrectly aligned rods and pistons (c) Checking centering of rod between piston bosses in engine
5. Installing new rings on piston	(a) Types and purpose of piston rings (b) Recommendations of ring manufacturers for various cylinder conditions (c) How to check ring clearances
6. Reconditioning cylinder	(a) Use of micrometers and cylinder gauges (b) How to use cylinder hone (c) Use of cylinder boring bar (d) How to check piston clearances (e) How to deglaze cylinders
7. Reconditioning pistons	(a) Knurling of pistons - advantages and disadvantages (b) Regrooving of pistons and the use of spacers (c) Piston expanders and when they should be used
8. Installing pistons, rings and rods in cylinder	(a) Use of ring compressor (b) Precautions necessary

AN ANALYSIS OF THE MOTOR VEHICLE REPAIR TRADE

BLOCK 27: Engines

UNIT 7: Manifolds

OPERATIONS

1. Removing and replacing intake
and exhaust manifolds

KNOWLEDGE

- (a) Correct installation of gaskets
- (b) How to clean the manifold
passageways and the importance of
this
- (c) Dangers of exhaust leaks
- (d) Effect of intake manifold leaks
on engine performance
- (e) How to check manifold, carburetor,
heater tubes and valves



